A Summary of Current Program and
Preliminary Report of Progress

SUGAR RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report is primarily a research tool for use of Department scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs. The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
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Agricultural Research Service (ARS)

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Crops
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The other type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

1 Cross Commodity Research of Agricultural Engineering, Crops, and Entomology Research Divisions
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A copy of any of the reports may be requested from James F. Lankford, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

INTRODUCTION

This report deals with work directly related to the production, processing, distribution, and consumption of sugarcane, sugarbeets, and sweet sorghum. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only sugar problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organizational unit reports of the several divisions.

The report covers Farm Research; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. As shown in the table of contents, there is a breakdown of the research program by problem areas.

For each area there is a statement of (1) the Problem, (2) the U.S.D.A. Program, (3) A Summary of Progress during the past year on U.S.D.A. and cooperative work, and (4) a list of Publications resulting from U.S.D.A. and cooperative work.

Research on sugar crops is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the ten State Agricultural Experiment Stations, and (3) private funds allotted, largely by sugar industries, to research carried on in private laboratories or to support of State Station or U.S.D.A. work.

Research by USDA

Farm Research in the Agricultural Research Service comprises investigations on introduction, breeding, and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. It is carried out in the following divisions: Crops, Entomology, and Agricultural Engineering. The work involves 62 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to the chemical and physical properties, new and improved products, and new and improved processing technology for both sugarcane and sugar beets. It is carried out in the following research divisions: Southern, Western, and Northern Utilization. The work in these divisions involves 19 professional man-years of scientific effort.

Marketing and Economic Research is done in three services. Sugar research in Agricultural Marketing Service deals with the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer There is no current work in this area. Economic research conducted in the Economic Research Service deals with marketing costs, margins and efficiency; market potential, supply and demand, and outlook and situation.

Research in cooperative marketing is conducted by the Farmer Cooperative Service. The work reported herein is done by the following divisions: Marketing Economics, Economic and Statistical Analysis, and Marketing. The sugar research in these services involves 2.5 professional man-years of scientific effort.

Interrelationships Among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects sugar research is carried on by 10 of the 53 State Agricultural Experiment Stations. The types of work to which the largest amount of effort is devoted include breeding and genetics, diseases, variety evaluation, insect control, weed control, agricultural engineering, utilization and marketing and economics. There is a regular exchange of information between Station and Department scientists to assure that the programs complement each other, and to eliminate unnecessary duplication.

Research by industry and other organizations is sponsored primarily by beet and sugarcane companies, processors, sugar refiners, and chemical companies.

Beet sugar companies conduct applied research on breeding and genetics, nutrition, and agronomic practices, including production and processing of sugar beet seed. The Department supplies new varieties and conducts the basic research needed by the beet sugar companies in their research program.

Large companies that grow sugarcane in Florida, Louisiana, California, Puerto Rico, and Hawaii conduct research on breeding, variety evaluation, cultural practices, fertilization, and the use of chemicals to expedite (1) the accumulation of sugar in sugarcane and (2) harvesting operations. Valuable developments from such research is made available to Federal and State scientists who cooperate by conducting the basic research necessary to such activity.

Chemical companies conduct research for the development of more effective fungicides for the control of diseases which attack sugar crops and for seed dressings. Also some chemical companies are engaged in the formidation of chemicals for use as desiccants, as fungicides, as growth

stimulants, and as retardants to hasten maturity of sugarcane. Federal and State groups provide the basic and fundamental phases essential to this area of research.

Basic research done by the Department and States will be utilized by industry and other organizations in their research programs, especially in the further development of improved products and equipment. Industry's cooperation in supporting sugar research at Federal and State Stations has contributed greatly to its success.

I. FARM RESEARCH

SUGAR PLANT CULTURE
BREEDING, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Sugar production in the United States is below national consumption. For more than a quarter century our sugar requirements have been provided through quotas of domestic production and foreign importations established by Acts of Congress. Sugar crops, which are nonsurplus, have major problems pertaining to quality and efficiency of production. These problems have acquired broader meaning with the implementation of the Sugar Act Amendment of 1962 which provides for growth and expansion of the domestic sugar industry.

Major diseases of sugar crops, especially virus yellows of sugarbeets and ratoon stunting of sugarcane, unfavorably affect quality and continue to take a heavy toll of production. New strains of the curly top virus of sugarbeets and of the mosaic virus of sugarcane have been discovered. They are capable of severely damaging varieties that are resistant to strains of these viruses formerly prevalent in a region. The major diseases, as well as new strains of the pathogens, are serious hazards to stable production of sugar crops in all regions of the country.

Soil-inhabiting pathogens attack the root systems of sugarbeets and of sugarcane, inflicting heavy losses; and the microbial flora of the rhizosphere may have a bearing on the failure of sugarcane plantings to endure repeated harvest and regrowth and on the decline in variety productivity. Basic information on the etiology and epidemiology of diseases of sugar crops is urgently needed for the development of methods of control through the application of direct measures, biological antagonism, and breeding for resistance.

Germ plasm is available which could provide factors for resistance to most of the major sugarbeet pathogens, including the cyst nematode. Breeding should be accelerated to utilize this wealth of germ plasm in the development of resistant lines, varieties, and hybrids. The bank of germ plasm of sugarcane and sweet sorghum has been greatly enriched through importation of breeding material, and the World Collections of these crop plants should be further utilized in the development of productive varieties that are of high quality, resistant to disease and insects, and tolerant to low temperature.

The application of improved field practices of culture and nutrition to sugar crops has resulted in a marked increase in acreable yield of beets and cane, but sucrose percentage has shown a

downward trend. Expanded research is needed to establish fundamental principles in physiology and genetics, whereby concomitant improvement can be brought about in both quality and yield under high levels of fertility. Basic research is needed to give a better understanding of genetic, cytoplasmic, and environmental factors conditioning male sterility in sugar crops and to provide information on techniques for the use of this character as a tool in hybrid seed production. The labor requirements for sugar production should be reduced through the development of varieties of sugar crops that are suitable for mechanized farming.

PROGRAM

The Department has a continuing program of basic and applied research on regional problems of sugar crops which relate to disease control, quality, and efficiency of production. The solution to these problems involves studies pertaining to agronomy, breeding, genetics, physiology, and plant pathology. The long-term program of applied and basic research on breeding and genetics of sugar crops at all major stations is aimed at the production of inbred lines, varieties, and hybrids that are resistant to diseases, nematodes, and insects; tolerant to low temperature; improved in quality and yield; and suitable for mechanized farming. The research on diseases of sugar crops includes studies on identification and transmission of the causal agents, means of infection, host range, epidemiology, and control. Variety evaluations and studies on physiological and cultural factors influencing quality are important phases of research at all major sugar crops stations.

Sugarcane breeding at Canal Point, Florida, is cooperative with Agricultural Experiment Stations in Florida, Louisiana, and Mississippi; and with representatives of the sugarcane industry in these states. In Puerto Rico, sugarcane breeding is cooperative with the Agricultural Experiment Station and the sugarcane industry. Sweet sorghum breeding at Beltsville, Maryland, and Meridian, Mississippi, is cooperative with Agricultural Experiment Stations in Louisiana, Mississippi, Alabama, Georgia, South Carolina, Tennessee, Kentucky, and Texas. Disease control and cultural research on sugarcane and sweet sorghum are carried out in Louisiana, Mississippi, Florida, and Georgia, in cooperation with State Experiment Stations. Sugarcane research in California is cooperative with growers. Research in Hawaii is conducted cooperatively with the industry.

The sugarbeet research programs at Logan, Utah, and at Fort Collins, Colorado, are conducted in cooperation with their respective State Agricultural Experiment Stations as well as with the Beet Sugar Development Foundation; at Salinas, California, and Beltsville, Maryland, in cooperation with the Beet Sugar

Development Foundation; and at East Lansing, Michigan and St. Paul, Minnesota, in cooperation with the respective State Agricultural Experiment Stations.

Sugarbeet research on breeding at University Park, New Mexico, in cooperation with New Mexico Agricultural Experiment Station, was closed out July 30, 1962 and the funds transferred to Logan, Utah.

The Federal scientific effort devoted to research in this Area totals 48.0 professional man-years. Of this number, 22.7 are devoted to breeding, 8.9 to diseases, 8.7 to variety evaluation, 6.4 to cultural studies, and 1.3 to program leadership. These man-years are distributed for the crops as follows: Sugarbeets - 14.4 breeding and genetics; 4.0 diseases; 3.6 variety evaluation-quality; 2.7 culture-physiology; and 0.8 program leadership: Sugarcane and sweet sorghum - 8.3 breeding and genetics; 4.9 diseases; 3.7 culture-physiology; 5.1 variety evaluation-quality; and 0.5 program leadership.

A contract was executed August 1, 1961 for research on "Breeding by Induction of Polyploidy in Sugar Beet and Rye" with Estacion Experimental de Aula Dei of the High Council of Scientific Research, Zaragoza, Spain under Public Law 480 and is known as Research Grant No. FG-SP-120 (Project E25-CR-5). It is estimated that the work on sugarbeets under this contract will amount to 1.0 man-year over the 5-year period of the contract.

PROGRESS

A. Breeding

1. Sugarbeets

Monogerm varieties. The development of monogerm hybrids suitable for most regions of sugarbeet production is a noteworthy accomplishment of the U. S. Department of Agriculture and cooperators in the beet sugar industry and seed producing enterprises. From a small production of an experimental hybrid in 1955, the percentage of monogerm seed has shown a progressive upward trend, and in 1962 the sugarbeet seed crop was 88.5 percent monogerm.

Varietal changeover from multigerm to monogerm varieties, with a significant reduction in labor requirements for weeding and thinning, will be attained in 1963 for a major portion of the sugarbeet acreage in this country. Monogerm seed, which now characterizes the American sugarbeet, was derived through genetic procedures from a single unthrifty plant found in 1948.

The monogerm seed character is being emphasized in the basic breeding work conducted at Salinas and Brawley, California, Logan, Utah, Fort Collins, Colorado, East Lansing, Michigan, and Beltsville, Maryland. Eleven of the 15 new developments of breeder seed released from these stations in 1962 for further evaluation were monogerm.

Cytoplasmic male sterility is the genetic device used to bring about commercial production of hybrid seed. Basic research is being conducted at Logan, Utah, and Fort Collins, Colorado, to determine the influence of environment on the expression of the character. Research at Salinas, California, has shown that cytoplasmic male sterility remains stable in expression when tetraploidy is induced in diploid plants and inbred lines. Therefore, diploid male-sterile lines can be converted to tetraploid lines for use as female parents in the production of triploid hybrids. The likelihood of obtaining larger triploid seed from the hybridization of a tetraploid male-sterile as female parent and a diploid as pollinator than from the reciprocal combination is of importance with monogerm sugarbeets.

The cytoplasmic factors conditioning male sterility in the sugarbeet were postulated from the mode of inheritance of the character. Cytoplasmic factors conditioning male sterility in some plants have been transmitted in the manner of viruses through grafting of vegetative tissue. In research at Logan, Utah, grafting techniques that transmitted the curly top virus from a male-sterile stock to a healthy pollen-fertile scion did not demonstrate the transfer of the cytoplasmic factors conditioning pollen production.

Diploid hybrids produced from parental lines developed at Salinas, California, continue to give outstanding performance in that State. Approximately 1.5 million pounds of sugarbeet seed was produced in 1962, for use in California, and of this production 30 percent comprised "US" hybrid combinations such as US H6, and 69 percent comprised company hybrids in which a "US" male sterile was used as the seed parent. Thus the basic and applied breeding research at Salinas, California, contributed significantly to the sugarbeet varieties used in that State.

Triploid hybrids in cooperative tests conducted in California and Michigan gave higher yields of gross sugar than the diploid hybrids, but in some instances the triploid hybrid was lower in percentage sucrose than the diploid. In tests conducted in Utah, Colorado, Michigan, and Maryland, some triploid hybrids suffered greater damage from disease than did the diploid hybrids, while other triploids were more resistant to disease than related diploid hybrids. Triploid hybrids obtained by using European tetraploid lines as pollinators and American diploid male-sterile lines as seed parent failed to perform significantly better than the diploid hybrids in the same tests.

Polyploidy has shown unexpected influence on the expression of characters in the sugarbeet. In previous reports it has been pointed out that sugarbeet populations were improved in disease resistance when tetraploidized. At Salinas, California, a population derived from seed treated with colchicine, a tetraploidizing agent, has shown striking tolerance of the tetraploid plants to the spider mite or a remarkable preference of the pest for the diploid plants. In field trials at Fort Collins, Colorado, and Beltsville, Maryland, tetraploid lines were more resistant to leaf spot than the diploids from which they were derived, and a similar relation has been shown for curly top in tests conducted at Logan, Utah.

Induction of autotetraploidy in the sugarbeet constitutes a significant part of the research conducted at Salinas, California, Logan, Utah, Fort Collins, Colorado, Beltsville, Maryland, and Zaragoza, Spain. Funds for support of work on tetraploidization in Spain are provided through a grant under PL 480.

Hybrids for early harvest. Basic research on breeding and genetics at Fort Collins, Colorado, has demonstrated that populations can be bred which will produce satisfactory yields of roots, percentage sucrose, and apparent purity when harvested a month earlier than presently grown commercial varieties. Such hybrids planted on a portion of the acreage would make it feasible to start harvest and processing from 2 to 4 weeks earlier than is the present practice.

2. Sugarcane

Sugarcane breeding to develop improved varieties having high quality, resistance to diseases, insects, and cold damage, and that are adapted for mechanical harvesting is carried out at Canal Point, Florida; Houma, Louisiana; Meridian, Mississippi; and Cairo, Georgia.

Parental clones having the desirable characteristics are crossed at Canal Point to produce seedling progenies for testing in Louisiana, Mississippi, Georgia, and Florida. Superior clones from crosses in previous years constitute the major source of germ plasm. New parental clones are developed through hybridization of cultivated and wild forms of Saccharum and with the related genera Sorghum, Erianthus, Miscanthus, and Sclerostachya.

Cytogenetic studies are conducted at Beltsville, Maryland, to determine cytological behavior in intra- and interspecific hybrids and the usefulness of various sources of germ plasm in the breeding program.

Crosses at Canal Point in the 1962-63 season involved approximately 100 biparental combinations which produced 202,799 viable seed. Approximately 32,000 seed from crosses of cold resistant parents to produce varieties adapted to conditions in Louisiana and new areas of sugarcane production in Florida.

Seedlings are screened for resistance to mosaic prior to setting them in the field. Improved inoculation by spraying the plants with a suspension of the mosaic virus made it possible to eliminate approximately 50 percent of the seedlings in 1963 because of susceptibility to mosaic.

Selections of promising seedlings in Louisiana, Florida, Mississippi, and Georgia exceeded 8,000 during 1962. These selections are currently being tested in various sugarcane producing areas in cooperation with Agricultural Experiment Stations, the American Sugarcane League, and the Cairo Cane Growers' League.

Inheritance studies were carried out in Louisiana in 1962 to determine the resistance in seedling progenies to mosaic. Seedlings from crosses of susceptible and resistant parents were used in the study.

Promising selections for agronomic tests are screened for cold resistance in Louisiana. Varieties superior in growth, sugar content, and disease and cold resistance are evaluated in variety experiments at 16 locations in cooperation with Agricultural Experiment Stations and growers in Louisiana, Florida, Georgia and Mississippi.

3. Sweet Sorghum

Development of hybrid varieties having superior yielding and sugar producing qualities and that are resistant to diseases constitute an important part of the sweet sorghum breeding program. Incorporation of cytoplasmic male sterility in sweet sorghum lines has made this research possible.

Crosses of parental lines were made at Beltsville, Maryland and Meridian, Mississippi in 1962; segregating populations were evaluated in Mississippi, Georgia, Maryland and California. Selections promising for commercial culture are evaluated in cooperation with Agricultural Experiment Stations in Louisiana, Mississippi, Alabama, Georgia, Tennessee, South Carolina, and Florida. Data from 11 experiments in 1962 show that Wiley is a superior variety for sirup production; this was the only variety that produced a high quality sirup at all locations. A new variety, Mer. 55-1, was superior for sugar production in Louisiana and Texas.

Inheritance studies at Meridian, Mississippi, show that the orange color of the stalks is inherited as a simple recessive to normal but appears to be linked with an epistatic gene with 20.27 percent crossing over in the coupling phase. Resistance to insecticides and herbicides in segregating populations show the possibility of developing varieties highly resistant to damage from the chemicals.

Promising new lines based on evaluations under a range of conditions will be released for commercial culture. Mer. 55-1 will be recommended for release in 1963.

B. Diseases

1. Sugarbeets

Virus diseases of sugarbeet adversely affect quality as well as yield and thereby decrease processing efficiency and reduce financial returns to both the grower and the processor. The depressing effect of virus diseases on root yield is generally recognized, but the influence on quality may be overlooked or incorrectly attributed to other causes. Pathological research at Salinas, California, and Logan, Utah, concerns beet yellows, western yellows, mosaic, and curly top, including appraisal of damage, host range and dissemination of the viruses, and vector relations. The development of resistant varieties seems feasible and the most promising method of combating these virus diseases. Extensive programs of screening breeding material and exotic forms of beet are conducted at these stations to locate sorts that are resistant to the viruses.

Fungus diseases of sugarbeet seem to be gaining in intensity. The increase in damage in recent years can be attributed, in part, to

a lower level of resistance in the new monogerm varieties than formerly found in the multigerm varieties which were the object of many years of research. At Fort Collins, Colorado, East Lansing, Michigan, and Beltsville, Maryland, emphasis is placed on breeding monogerm varieties that are resistant to leaf spot and black root; and at Fort Collins, Colorado, on breeding for resistance to Rhizoctonia root rot.

Beet yellows and western yellows, which are manifest by similar symptoms but unlike in host range, continue to cause serious damage to the sugarbeet crop in California and the Pacific Northwest. The incidence of yellows in Colorado was more noticeable in 1962 than in the past decade. Field tests in California confirm previous reports that beet yellows infection shortly after thinning reduces root yield as much as 40 percent and causes a significant reduction in percentage sucrose. Field tests in California demonstrated progressive improvement in yellows resistance, but a level of tolerance has not been attained to characterize a new locally adapted variety. Western yellows is not as severe as beet yellows. Unfortunately, infection by one of the viruses does not give protection from infection by the other, and the damage caused by double infection is essentially the sum of the damage induced by each of the two viruses when occurring alone.

Mosaic virus occurs in epidemic proportions in California and the Pacific Northwest. Although the importance of the virus has not been fully appraised, previous research has shown that the virus is capable of causing a significant loss in root yield and a measurable reduction in yield of sugarbeet seed. At Salinas, California, research has revealed that the sugarbeet mosaic virus in that State is a complex of strains varying in virulence. In some areas the virulent strains are the most prevalent.

Noninfectious yellowing of sugarbeet has been investigated in California, Oregon, and Washington. The symptoms simulate virus yellows, but the causal agent is not infectious. The yellowing is evident in seedlings soon after thinning but does not persist in the later stages of growth. The occurrence of noninfectious yellowing is most frequent in sugarbeets grown in saline soils and is associated with relatively low temperatures.

Curly top virus has been revealed through research at Salinas, California, and Logan, Utah, as a complex of strains that differ markedly in their ability to cause damage to varieties of sugarbeet. In 1962 a virulent strain of the virus was found in Utah that was capable of inflicting severe damage in a variety that had been resistant to the prevalent strains in the region. To meet the threat that virulent strains of the virus may become the dominant ones, effective greenhouse techniques are being developed to facilitate breeding for resistance to a specific strain of the virus.

Black root resistance assumes greater importance with current trends in field practices for precision planting of monogerm seed to give the desired plant population without thinning. The application of greenhouse techniques at Beltsville, Maryland, for more precise selection of resistant genotypes has imparted greater effectiveness to breeding for black root resistance. It is evident that seedlings of varieties now being synthesized will be able to survive under more severe exposure to soilborne pathogens inducing black root than varieties now in use.

Rhizoctonia root rot investigations at Fort Collins, Colorado, are devoted largely to the application of field techniques for the identification and isolation of resistant genotypes. Field evaluations of many accessions of exotic forms of beet did not reveal new sources of resistant germ plasm. Presently the research effort is being directed to promising sources of tolerant plants in the cultivars of sugarbeet.

Leaf spot damage seems to be increasing in the eastern sugarbeet districts. Although weather conditions may have been more favorable for the disease during 1961 and 1962, the changeover from multigerm to monogerm varieties with less resistance to the pathogen has been a major factor in the buildup of leaf spot damage. Pathological investigations on leaf spot and other diseases of sugarbeet are being expanded in Minnesota and Michigan, and the programs of breeding for leaf spot resistance are being strengthened to combat current losses.

Nematode diseases of sugarbeet assume greater importance with the demonstration that the eelworm is an accessory to damage induced by other soil-inhabiting pathogens. Breeding research at Salinas, California, has shown remarkable progress in the development of basic breeding lines that are tolerant to the sugarbeet cyst nematode and associated soil-inhabiting organisms. In field trials on soils heavily infested with the nematode, several accessions of breeder seed developed in the selection program have yielded 40 percent more roots than the unselected commercial variety.

2. Sugarcane

Current research on diseases of sugarcane has been reoriented to include studies on the varietal yield decline problem. This additional research will be coordinated with investigations on control of two major virus diseases, mosaic and ratoon stunting. Both virus diseases are apparently related to the varietal yield decline problem.

Mosaic. Studies are in progress at Houma and at Canal Point to identify clones of sugarcane in the World Collection that are resistant to current strains of the mosaic virus. Resistant clones

are crossed with selected parental varieties to develop commercial-type varieties that are not susceptible to the disease.

Inoculation of large seedling populations with the mosaic virus by a spray technique has greatly increased the efficiency of this work. In 1963 approximately 50 percent of the seedlings at Houma and Meridian were eliminated because of susceptibility to mosaic.

Insect vectors in Louisiana cause a rapid spread of the mosaic disease. Research in progress indicates that one or more new vectors are involved. Further tests are needed to identify completely all of the vectors.

Ratoon stunting disease. Research on the ratoon stunting disease was concentrated at Houma in 1962, on varietal resistance, role of the disease in yield decline, and relative effectiveness of hot water and hot air treatment of seedcane for controlling the disease. Hot water was equal to hot air for treating seedcane in Louisiana.

There is no effective resistance to the disease in commercial varieties. The disease spreads rapidly through mechanical handling at the time of harvest. Treatment of seedcane with hot air or hot water prior to planting is the only known means of controlling the disease. There is no apparent relationship between ratoon stunting disease infection and susceptibility to red rot. Increase in mosaic following heat treatment to control the ratoon stunting disease is associated with early growth of the plants from the treated seedcane.

Red leaf disease, discovered in Louisiana in 1961, was found in two additional locations in 1962. No pathogenic organism has been found in diseased tissue. The disease is apparently caused by a virus. Further studies are in progress to assess the commercial importance of the disease.

Red rot was prevalent in many areas of Louisiana during the spring of 1963. There was little injury to seedcane from low temperatures in December 1962 and January 1963, however, this condition apparently favored development of the red rot organism.

3. Sweet Sorghum

Red rot. A tractor mounted sprayer was used successfully in 1962 to inoculate large segregating populations of sweet sorghum with anthracnose (Colletotrichum Graminicola). The rate of infection was equal to that from hand inoculation.

Mosaic. It was established in 1962 that high light intensities for a few hours preceeding inoculation reduces the susceptibility of sweet sorghum plants to infection by the sugarcane mosaic virus.

Preliminary evidence indicates that the light effect does not involve the phytochrome system.

Zonate leaf spot (Gloeocercospora sorghi). Current research indicates that apparent resistance to the disease is not clearly evident in young plants. The most resistant varieties appear to first become infected with the organism and then recover. Studies are in progress to identify the type of resistance involved.

Pokkah-boeng (Gibberella moniliformis) developed in many varieties of sweet sorghum during 1962. The infection was apparently related to seasonal conditions. Further studies are needed to assess importance of the disease in sweet sorghum production.

C. Variety Evaluations

1. Sugarbeets

Cooperative variety tests conducted in the Great Lakes region in cooperation with the Farmers and Manufacturers Beet Sugar Association and the Michigan Agricultural Experiment Station have shown satisfactory root yields for monogerm hybrids, but they are in need of improvement in sucrose percentage and disease resistance. These tests demonstrated an improvement in leaf spot resistance of new monogerm lines and in experimental hybrids; therefore, more desirable parental lines are available as replacements for those now in use.

Hybrid varieties were evaluated in California through the cooperation of sugar companies that are members of the Beet Sugar Development Foundation. The extensive tests have demonstrated that a new monogerm hybrid which is now available is a satisfactory replacement for the multigerm hybrids currently in use in that State.

Hybrids carrying resistance to leaf spot and curly top were evaluated in Colorado, Kansas, and California in cooperation with Colorado Agricultural Experiment Station, Kansas Agricultural Experiment Station, and the Beet Sugar Development Foundation. Emphasis is being placed on multiple disease resistance in breeding programs at Fort Collins, Colorado, Logan, Utah, and Salinas, California.

2. Sugarcane

New varieties developed in the breeding program in Florida and Louisiana are evaluated for commercial production in cooperation with Agricultural Experiment Stations in Louisiana, Florida, Mississippi, Alabama, Georgia, the American Sugarcane League and the Cairo Cane Growers' League. Evaluations in 1962 were made on different soil types and under different growth conditions for sugar and sirup production.

Cold resistant varieties were tested in Florida in 1962. C.P. 57-526 and C.P. 57-614 were superior for cold resistance and comparable to commercial varieties in yields of sugar per acre. Further tests are needed to evaluate these varieties.

New varieties in Louisiana produced yields comparable to current commercial varieties. Two of these, C.P. 50-30 and C.P. 57-98, gave the best results in eleven experiments. The ability to produce good yields in stubble crops and favorable results as plant cane indicates that C.P. 50-30 may be promising for commercial production in Louisiana.

Variety response to soil types has decreased during recent years in Louisiana. In 1962 the yield of cane and sugar per acre on heavy clay soil was comparable to that on light soil in most areas. Decrease in varietal response to soil types is thought to be associated with improved cultural conditions and the wider adaptability of new varieties.

C.P. 52-48, released for commercial culture in Georgia in 1958, continues to be superior for sirup production in that area. The favorable stubbling qualities of the variety and its ability to produce tillers early in the spring that rapidly cover the land are considered to be good characteristics of the variety.

3. Sweet Sorghum

New varieties of sweet sorghum developed in breeding programs at Beltsville, Maryland and Meridian, Mississippi are tested in cooperation with Agricultural Experiment Stations in Louisiana, Alabama, Georgia, South Carolina, Kentucky and Tennessee for sirup production and for sugar production in Louisiana and California. Limited tests are conducted in Texas in cooperation with growers and at Beltsville, Maryland. Evaluations of varieties are made on different soil types and under different growing conditions.

Mer. 55-1 proved superior for sugar production in tests during 1962 in Louisiana and Texas. Yields of stalks per acre were comparable to that of commercial varieties and the sugar content was equal to that obtained from sugarcane in Louisiana. The variety appears to be well adapted to other areas and it is highly resistant to the common sorghum diseases. Data collected from experiments in progress will probably make it possible to release Mer. 55-1 for commercial production in 1963.

Mer. 60-2 was a superior variety for sirup production in 1962 in experiments in Georgia, Alabama, Louisiana, Mississippi, and South Carolina. In Tennessee the variety produced lower yields than current commercial varieties. Further tests are needed to completely evaluate the variety.

D. Culture-Physiology
1. Sugarbeets

Chemical treatments have shown specific influences on the metabolism of the sugarbeet in research conducted at East Lansing, Michigan, and Logan, Utah, but the treatments have not induced a significant improvement in quality.

Tetrazolium salts were evaluated as a means of testing the viability of sugarbeet pollen in research conducted at Fort Collins, Colorado. Eight tetrazolium salts were used in the tests. A chemical formulation of diphenyl tetrazolium bromide in 0.5 percent solution gave a staining reaction that was related to the percentage germination of the pollen on artificial medium. The staining reaction provides a specific and rapid means of determining viability of mature sugarbeet pollen.

Seed germination of some new developments in breeding research at Salinas, California, was strikingly improved by removing caps from the ovarian cavities of the fruits. The tests clearly indicate that low germination in the seed samples was due to failure of moisture to penetrate the tough tissue surrounding the true seed. Research conducted at East Lansing, Michigan, has shown that oxalates in the seedball tissue are inhibitors to germination of sugarbeet seed. In a test involving 36 samples, the oxalate content of the seed could be correlated with the speed of germination. The germination of sugarbeet seed after 35 years in cold storage in Utah is of much interest to sugarbeet breeders.

Concentration of amino acids in leaves of the sugarbeet are markedly influenced by the beet yellows virus. In infected leaves, the concentration of total amino acids decreases to about half of that found in healthy leaves. Citrulline and alanine, representing only 18 percent of the amino acids in leaves of healthy plants, may amount to 45 percent of the total amino acids in infected leaves. Thus the relative concentration of total amino acids and of individual amino acids gives a measure of the extent to which the metabolism has been disturbed by the virus and may be taken as an indication of genetic variability in tolerance within a population.

Reduction in number of cysts of the sugarbeet nematode in the soil and the subsequent reduction of the incidence of female eelworms on a crop of sugarbeets, following growth of leguminous crops, have been demonstrated in cooperative experiments at Salinas, California. The influence of preceding crops on the soil flora of sugarbeet pathogens has direct bearing on efficiency of production as well as on control of black root and root rots.

2. Sugarcane

Maturity of sugarcane varieties differs greatly in Louisiana. C.P. 48-103 had 61 percent more sugar per ton of cane on September 24, 1962, than C.P. 44-101, the standard commercial variety. Early maturity of C.P. 48-103 provides mill cane during the early part of the harvesting season.

Increase in yield of sugar per ton of cane of C.P. 44-101 during a seventy day period from September 24 to December 3 was 1.7 pounds per day. This consistent increase in yield of sugar indicates the importance of delaying harvest as long as possible.

Chemicals were applied to sugarcane in Louisiana to determine their effect on maturity. Of nine chemicals tested AMAB influenced maturity to the greatest extent; however, the results are not significant. Some of the chemicals damaged foliage of the plants.

Fertilization at the rate of 80 and 120 pounds of nitrogen per acre was compared in 20 experiments in Louisiana during the period 1956-62. The highest rate of nitrogen increased the yield of cane per acre 0.77 tons and of sugar per acre 63 pounds. There was an average reduction of 0.15 in the sucrose percentage.

A complete fertilizer (N, P_2O_5, K_2O) increased the yield of cane per acre 0.23 tons and the yield of sugar per acre by 444 pounds in Louisiana in 1962 as compared to applications of only nitrogen. Mixtures containing 60 pounds of P and of K gave slightly higher but not significantly greater yields of sugar per ton of cane than comparable applications of nitrogen.

Trash plowed into the soil after harvest or before planting the crop in Louisiana increased the yield of cane per acre by 0.25 tons and the yield of sugar by 260 pounds. These differences were not significant.

Desiccants sprayed on sugarcane plants required one week to desiccate the leaves enough for burning in Louisiana. Two chemicals, Paraquat and Diquat were the most effective desiccants. Desiccation was most rapid during sunny weather. When desiccation of leaves was effective there was a reduction in sucrose.

Selective topping of sugarcane at Houma in 1962 indicated the possibility of improving the net return to the grower by increasing the sucrose content of mill cane. Optimum topping depends on the variety and growth conditions. The sucrose content of mill cane may be increased up to ten percent by selective topping of varieties that have a high degree of variability in stalk length.

Growth patterns varied greatly with varieties under conditions in Louisiana in 1962. C.P. 44-101 had the most rapid rate of growth early in the season but C.P. 52-68 and C.P. 36-105 surpassed it during the latter part of the season.

Freeze damage to sugarcane in Louisiana during December 1962 was influenced by two characters; resistance of the stalk parenchyma to freezing, and resistance of the juice to deterioration following a freeze. Both of these factors vary with varieties.

Tissue damage from cold based on the percentage of weight of frozen tissue was a reliable basis for separating varieties into susceptibility categories at Houma. Further studies and refinements of the technique are needed.

Susceptibility to freeze damage is associated with moisture content of the plant and light conditions at time of the freeze. Studies are in progress in Louisiana to assess with greater precision the relative effect of each of these factors.

Flowering of sugarcane is influenced by night temperatures. In Hawaii minimum night temperatures of 65°F. and below during the differentiation period can prevent floral initiation. The critical time for minimum night temperatures is September 1 to 25. This period is known as the differentiation period.

Control of flowering is important in most tropical areas. In Hawaii a new chemical known as Diquot inhibited flowering to about the same extent as maleic hydrazide, the standard treatment. Further tests are needed to evaluate the usefulness of Diquot for controlling flowering.

Preservation of sugarcane tassels during crossing by submerging stalk ends in a solution of SO_2 has been a common practice in many countries. In Hawaii, hydrazine sulfate added to the SO_2 solution improved its effectiveness for storing tassels in 1962.

Stripping leaves from sugarcane was ineffective in improving the yield or quality of sirup in Mississippi. Sirup samples of commercial varieties from stripped and unstripped stalks were used to evaluate harvesting practices.

3. Sweet Sorghum

Propazine applied as a pre-emergence spray controlled weeds effectively in sweet sorghum for four weeks at Meridian. Supplementary applications were needed for continuous control. Chemical analyses show no trace of propazine in sirup samples.

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WEED AND NEMATODE CONTROL
Crops Research Div., ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective, chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, greatly increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has long been known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on sugar crops.

USDA PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups. The work is cross commodity in nature. The weed control program involves a total of 66 professional man-years. Of this total, 1.8 is specifically directed to weed control in sugar crops. The program is being conducted in Prosser, Washington; St. Paul, Minnesota; and Houma, Louisiana.

The Federal scientific effort devoted to basic and applied nematode research is 21.5 professional man-years, of which 3.0 is devoted to applied research in sugar crops at Salinas, California; Baton Rouge, Louisiana; and Logan, Utah.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Weed Control

a. Sugarcane. Triazine, thiolcarbamate, uracil, and phenylacetic acid herbicides were evaluated for selective preemergence control of broadleaved weeds and annual grasses in sugarcane at Houma, Louisiana. Simazine and 2-methoxy-4,6-bis(isopropylamino)-s-triazine (prometone) were superior to five other s-triazine compounds at 4 lb/A. EPTC and PPTC at 5 lb/A were superior to three other thiolcarbamates for control of crabgrass and seedling Johnsongrass. Isocil at 2 lb/A was found to be an excellent preemergence treatment for the control of seedling grasses, but caused injury to sugarcane. Preemergence applications of 2,3,6-trichlorphenylacetic acid (fenac)

at 4 and 8 lb/A on silt loam soils controlled seedling Johnsongrass, crabgrass, and a broad spectrum of broadleaved weeds for 120 days without reducing sugarcane yields. Layby applications of fenac at 8 lb/A consistently reduced yields of sugarcane. Sugarcane was also severely injured when high concentrations of fenac were allowed to come in contact with developing roots.

Postemergence applications of diuron at 4 and 12 lb/A resulted in severe injury to sugarcane varieties CP 44-101 and CP 52-68, while variety N.Co. 310 was very tolerant. Sugarcane varieties were very tolerant to simazine treatments at 12 lb/A.

b. Sugarbeets. Weed-free beets produced 32 tons of roots per acre at Prosser, Washington. When annual weeds were not controlled, yields were reduced two-thirds to three-fourths. Annual weeds which grew uncontrolled in beets for more than 8 weeks reduced yields in proportion to the time they were allowed to remain before removal. EPTC at 3 lb/A or propyl ethyl-n-butylthiolcarbamate (PEBC) at 4 lb/A gave 100% barnyardgrass control when the herbicides were rototilled to depths of 1, 2, or 3 inches or layered at depths of 1, 2, or 3 inches. Layering appears to be a promising improved method of applying EPTC and PEBC. PEBC caused early-season crop injury, but the beets recovered fully.

B. Nematode Control.

Sugar. Investigations at Salinas, California, of a strain of sugar beet nematodes (Heterodera schachtii) which attacks tomatoes have shown that the virulence of the attack increases with prolonged association with tomato, and investigations are under way to determine if this race differs from other sugar beet nematodes.

In host tests of the sugar beet nematode at Salinas, California it was found that the Siberian Wallflower (Cheiranthus allionii) was highly susceptible, and that safflower is immune. Beta intermedia, Beta corolliflora and Beta macorrhiza, of interest as possible breeding material, were all found to be highly susceptible.

In experiments on the hatching of larvae from cysts of the sugar beet nematode at Salinas, no effect on hatching was noted with several antibiotics, amino acids, sugar beet phloem exudate, or various phosphate buffer solutions. A decrease in hatching was found with the addition of copper sulphate to exudate. Removal of eggs from the cyst was tried on the assumption that availability of oxygen might be a factor in hatching, but this made no difference; beet root diffusate was confirmed as the principal factor influencing hatching.

In a comparison of chemical treatments and crop rotations for control of the sugar beet nematode at Salinas, a rotation involving lettuce and corn increased yield from 13.6 to 16.5 tons of beets, and from 1.91 tons of sugar to 2.43 tons per acre. Treatment with the nematocide DBCP (1,2-dibromo-3-chloropropane) increased yield of beets to 19.5 tons of beets and sugar to 3.00 tons as compared to the untreated controls. Treatment with D-D Mixture (dichloropropane-dichloropropene) increased yields to 22.1 tons of beets and 3.43 tons of sugar. Average sugar content was 14.25% for the rotation plots and 15.45% for the plots treated with chemicals.

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SUGARCANE AND SUGARBEET INSECTS
Entomology Research Division, ARS

Problem. Insects and mites are major limiting factors in the production of sugar crops because of the direct damage they cause and the diseases they spread. The use of available insecticides to control insects on sugarcane and sugarbeets often leaves residues in the crop byproducts that makes them unsuitable for livestock feed. Heavy rains following applications of insecticides to sugarcane have resulted in some kill of fish in nearby streams. Safe, effective chemical methods are especially needed to control the sugarcane borer and the beet webworm. Sugarcane mosaic has become more important in recent years and information on insect vectors of this disease is needed. The beet yellows and the associated western yellows virus diseases of sugarbeets have become a threat to the sugarbeet industry and are particularly destructive in the Pacific Northwest. Emergency chemical control measures for the aphid vectors of the viruses of these diseases are urgently needed. The development of suitable control measures is handicapped by lack of adequate knowledge of the identity and ecology of the insect vectors and plant reservoirs of the two viruses. For long-range solutions to the problems, further investigations should be undertaken on parasites and predators of sugar-crop pests, on varieties of sugarcane and sugarbeets resistant to the insects involved, and on new insect control approaches such as the male-sterility technique or the development of attractants. Research should aim to develop control methods without objectionable features. Key insect pests that require heavy use of insecticides for their control and thereby make difficult the natural control of other pests on the same crops are special problems that should receive emphasis in the search for non-chemical methods of control.

USDA PROGRAM

The Department has a continuing long-range program involving basic and applied research on the insect problems of sugarcane and sugarbeet directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists, and chemists in the States where research is underway, and with industry. Studies on sugarcane insects are conducted at Houma, La., Canal Point, Fla., and Mayaguez, Puerto Rico, and on sugarbeet insects at Mesa, Ariz., Twin Falls, Idaho, Logan, Utah, and Yakima, Wash.

The Federal scientific effort devoted to research in this area totals 8.7 professional man-years. Of this number, 1.0 man-year is devoted to basic biology, physiology and nutrition; 1.9 to insecticidal control; 0.8 to insecticide residue determinations; 1.1 to biological control; 1.0 to insect sterility, attractants and other new approaches to control; 0.1 to evaluation of equipment for insect detection and control; 0.5 to varietal evaluation for insect resistance; 1.7 to insect vectors of diseases; and 0.6 to program leadership.

A P. L. 480 research grant (Project A7-ENT-1) has been made to the Commonwealth Institute of Biological Control, Bangalore, India, to study the natural enemies of sugarcane borers in India. Parasites and predators found effective for borer control will be made available for use in the United States.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Sugarcane Insects. In Louisiana the annual 1962 harvesttime survey to determine sugarcane borer infestation showed that 6% of the joints of sugarcane had borer damage with an estimated crop loss of 5%. The low infestation in 1962 resulted from 98% mortality in overwintering borers the previous winter. The infestation average for a 28-year period from 1935 to 1962, inclusive, is 16%. Twenty percent of 50 ratoon fields that were surveyed in June of this year had more than 500 borer-killed dead hearts per acre.

The 1962 harvesttime survey in Florida showed an average of 7.9% joints damaged by the borer for the Everglades area compared to an average of less than 2% for this area during the period of 1955-60. The sugarcane area near Fellsmere, Fla., had an average of 22.6% bored joints as compared to 21.4 in 1961, 19.1 in 1960, and an average of 8.9 during the period 1955-60.

2. Sugarbeet Insects. Biological and ecological studies of the beet webworm in southern Idaho have shown that it is probably the third brood of this insect that causes most damage in sugarbeets rather than the second. The studies have also shown that sugarbeets are not a preferred host, and consequently, the first two broods each season may build up on other hosts. Under laboratory conditions a much higher survival of webworm larvae is obtained from such weeds as redscale, Russian-thistle, and lambsquarters, than from sugarbeet plants.

3. Green Peach Aphid. Agamic forms of the aphid survived the winter of 1962-63 in the crowns of several perennial or fall-germinated weeds in the Yakima Valley of Washington. Aphids were particularly abundant on plants in the protected bottom of deep irrigation drain ditches in an area of intensive sugarbeet culture or along worn north banks of such ditches. Overwintering of this important aphid vector of the destructive beet western yellows disease on the weeds was shown to have particular significance--demonstrating that aphids collected from hoary cress, Lepidium draba, and several other common weeds found in the ditches were carrying the virus. Transfer of these aphids to healthy shepherd's purse (Capsella bursa-pastoris), an indicator plant, resulted in the development of typical beet western yellows symptoms.

At Mesa, Ariz., a handbook on insects affecting sugarbeets grown for seed was prepared for publication. This is based on more than 20 years of research and observation and more than 20 insects are described and

illustrated. The descriptions given permit easy recognition of the major pests of sugarbeets by seed growers and others. Information on beneficial parasites and predators of these pests, other control measures, and on the biology and habits of the insects is also included.

B. Insecticidal and Cultural Control

1. Sugarcane Insects. In experiments in Louisiana, granular insecticides, endrin, Guthion, Methyl-ethyl Guthion, Bayer 25141, U.C. 8305, and carbaryl, gave significant reductions in numbers of sugarcane borers. The most effective material was endrin with 90% control.

In Louisiana, small soil arthropods associated with root rot diseases of sugarcane were controlled with endrin at 1/2 lb. per acre, which increased yield 4.3 tons of cane per acre. Endosulfan at 4 lb. per acre increased the yield 3.4 tons; carbaryl at 4 lb., 1.3 tons; and chlordane (standard) at 2 lb. per acre, 1/3 ton.

In Florida, control of wireworms was attempted with insecticides applied to soils as emulsions. Their effectiveness was measured by increased yield in tons per acre, as follows: Phorate (4 lb. p/a.) 12.7 tons; diazinon (4 lb.) 12.1 tons; diazinon (8 lb.) 11.4 tons; heptachlor (4 lb.) 9.7 tons; aldrin (4 lb.) 8.4 tons; and chlordane (6 lb.) 4.6 tons per acre. Granular formulations increased yield as follows: Telodrin (1 lb.) 11.5 tons per acre; diazinon (6 lb.) 11.0 tons; heptachlor (4 lb.) 8.7 tons; aldrin (4 lb.) 5.5 tons; and chlordane (6 lb.) 3.6 tons per acre.

2. Sugarbeet Insects. Granular heptachlor applied as a soil treatment showed promise for controlling sugarbeet root maggot. Of 50 treatments tested in Idaho for control of this pest on sugarbeets, best results were obtained with 1/2, 1, and 2 pounds of heptachlor per acre. The heptachlor granules were mixed with the seed in drill rows at planting time. The maggot counts in 1/16 cubic-foot soil samples averaged 4, 3, and 2 for these treatments, respectively. There was little or no feeding on the roots except in the check plots where there was moderate to severe damage. Phorate applied in the same manner as heptachlor gave almost as good control but was phytotoxic. Less effective treatments included aldrin, V-C 13, Di-syston, ethion, and carbophenothion applied in the drill row at planting time; aldrin, dieldrin, phorate, V-C 13, and Di-syston applied in pelletized seed; and V-C 13, Menazon, and American Cyanamid 43073 in slurries applied to the seed.

Continued studies in Washington indicate the green peach aphid may be controlled on sugarbeet by applications of phorate or Di-syston to the young beet plants. The insecticide retarded the spread of beet western yellows disease and increased the yields of row beets and sugar. Additional studies are needed to determine how best to apply the insecticides and to develop a treatment program. Tolerances have been established for Di-syston but not for phorate.

Experiments in Utah continued to indicate certain sugarbeet insects may be controlled with insecticides either applied to pelleted seed or incorporated in the material used to pellet the seed. V-C 13 was most promising for control of the sugarbeet root maggot followed by phorate. The latter tended to be more effective than V-C 13 against the garden symphylan. Both materials gave promising results against the beet leafhopper. Both of these materials are considered to be systemic in plants and there is no established tolerance for them in or on sugarbeets. Di-syston which is also systemic and has tolerances established for dried pulp, roots, and tops has also given promising results against root maggots.

C. Insecticide Residue Determinations

Sugarbeets were treated at Twin Falls, Idaho, at planting time with 1/2, 1, or 2 lb. of heptachlor per acre by mixing the insecticide with the seed. Samples taken 113 days after planting and analyzed at Yakima, Wash., contained 0.17, 0.31, and 0.21 p.p.m. of combined heptachlor and heptachlor epoxide in the roots, respectively. One hundred and seventy-eight days after planting, the roots contained 0.09, 0.16, and 0.22 p.p.m. of the two chemicals. Measurable residues of heptachlor and heptachlor epoxide were found in sugarbeet crowns and foliage samples taken 178 days after planting in the case of the 1 and 2 lb. treatments but none in the case of the 1/2 lb. treatment. In view of these results, the use of heptachlor on sugarbeets cannot be recommended.

D. Biological Control

1. Sugarcane Insects. The population density of the West Indian sugarcane fulgorid in Florida has remained low since the spring of 1961. Two species of parasites, Stenocranophilus quadratus and Anagrus armatus, both introduced into Florida in 1959, are credited with the reduction of this pest to a low, non-economic population level.

Sugarcane borer parasitization by Agathis stigmaterus, introduced from Peru in 1932, in commercial fields of the Everglades and Fellsmere, Fla., areas at harvesttime 1962 was about double that reported in previous years, averaging 34 and 21%, respectively.

In Florida, preliminary biological studies of Goniozus indicus and Sturmiopsis inferens, two parasites introduced from India, in connection with P. L. 480 project A7-ENT-1, showed little promise of being able to establish themselves under field conditions in Florida. Results of tests with a third parasite, Apanteles flavipes, also from India, are more encouraging. Approximately 10,000 adults of this parasite have been reared and released in 4 locations in Florida.

Cuban flies survived two successive severe winters in Louisiana. Although low temperatures drastically reduced the overwintering borer population, minimum numbers of this introduced parasite survived. Several unemerged puparia were recovered during May and June from small borer collections of undetermined numbers. Parasitization in Puerto Rico averages 30% in the field.

Collections of borer eggs in fields of sugarcane on eight plantations in southeastern Louisiana during the fall of 1962 showed an average parasitism by Trichogramma of 32%, as compared to 39% in 1961. The usual average is 75%. In Puerto Rico, parasitization averages 75-90%.

Climbing cutworms appear to be suppressed by native parasites in sugarcane areas of Florida. Successive generations of climbing cutworms were not observed in cane of the Lake Okeechobee area this past season. Apanteles rufocafalis, Euplectrus plathypenae, Encelatoria rubentis and two ichneumonid species parasitized the cutworms heavily.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Sugarcane Insects. Studies at Mayaguez, P. R., for developing an artificial medium suitable for mass rearing of the sugarcane borer (Diatraea saccharalis) produced an inexpensive, easy-to-make, corn powder base material that appears to satisfy nutritional requirements. It is composed of distilled water, agar, sucrose, ascorbic acid, corn plant powder, and antibiotics.

Preliminary information suggests that sorbic acid may be instrumental in lengthening the larval life span of the sugarcane borer. Sugarcane borer sex ratios in Puerto Rico are about 1:1 on a year around basis. A high percentage (34-45) of field-collected old adult females lacked spermatophores.

F. Varietal Evaluation for Insect Resistance

1. Sugarcane Insects. Of 237 sugarcane varieties tested in hand-infested plots in Louisiana, in 1962, 50% had a lower infestation, and 55% produced more sugar per acre than standard variety C.P. 36-105. Of 319 varieties assigned C.P. and L. numbers in Louisiana in 1962, 20 were resistant to the borer, 19 susceptible, and the rest moderately susceptible to average. Two varieties, C.P.58-51 and L.56-25, now in advanced stages of development, were especially tolerant to borer infestation and have a good chance of becoming commercial varieties. Only one Florida variety, C.P.59-83, had a lower infestation than control variety, C.P.50-28.

G. Insect Vectors of Diseases

1. Sugarcane Insects. Spring populations of sugarcane mosaic vectors, the corn leaf aphid (Rhopalosiphum maidis) and the sowthistle aphids, Amphorophora sonchi and Macrosiphum ambrosiae, were higher in 1962 than in 1961. These species appear to be the most generally distributed of all known vectors.

At Houma, La., 16 weekly applications of demeton at 1/2 lb. per acre from October 25, 1961 to July 2, 1962, reduced sugarcane mosaic by 41%. Eighty-eight percent of the plants were free of the corn leaf and brick-red sowthistle aphids, 82% of the plants were free of the green pea aphid, and 68% of them were free of the sharp-nosed grain leafhopper.

2. Sugarbeet Insects. At Mesa, Ariz., field plot experiments showed that green peach aphids infected with the virus of either the beet western yellows or the beet yellows reduced the yield of sugarbeet seed. With beet western yellows yields were reduced 13%, and with beet yellows 17%; whereas, with a combination of the two viruses yields were reduced 26%. Symptoms are similar, although the viruses are unrelated. Beet yellows virus is semipersistent, most aphids losing the ability to transmit it in 24 hours. Beet western yellows is persistent in the aphid. Previous experiments had been with mixtures of these two yellows viruses, but the damage to the beet seed crop of either one alone was not understood. Several species of aphids transmit either or both of these viruses but the studies indicate the green peach aphid is the principal vector in Arizona.

The development of the green peach aphid on sugarbeet in relation to various overwintering sources of aphids and the subsequent occurrence of beet western yellows is being investigated in Washington. These studies have shown that aphids are more abundant in fields close to peach orchards where the aphids overwinter in the egg stage than in more remote fields even though the latter may be close to protected places where the aphids are able to feed during the winter. However, the incidence of beet western yellows tended to be higher in fields near these protected places indicating that the small number of active aphids from infected wild host plants is a more important source of virus infection than large numbers of aphids from peach orchards.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Insecticidal and Cultural Control

Entomology Research Division, USDA, and Louisiana State Entomology Department. 1963. Recommendations for Sugarcane Insect Control. Sugar Bulletin 41:194-195.

Gibson Kenneth E. and Joe T. Fallini. 1963. Beet leafhopper control in southern Idaho by seeding breeding areas to range grass. USDA, ARS 33-83:1-5.

Hensley, S. D., W. H. Long, E. J. Concienne, and W. J. McCormick. 1963. Control of First-Generation Sugarcane Borer Populations in Louisiana. Jour. Econ. Ent. 56:407-409.

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Biological Control

Burrell, R. W. and McCormick. 1962. Effect of Trichogramma releases on parasitism of sugarcane borer eggs. Jour. Econ. Ent. 55:880-82.

Insect Vectors of Diseases

Abbott, E. V. and L. J. Charpentier. 1963. Additional Vectors of Sugarcane Mosaic. Proceedings of the Eleventh Congress of the International Society of Sugarcane Technologists.

Charpentier, L. J. 1963. Sugarcane Mosaic-Vector Studies in Louisiana. Proceeding American Society of Sugarcane Technologists. Vol. 7B. Papers for 1959-60, Published March, 1963. (Previously published in July 1, 1961 Issue of Sugar Bulletin 39:222-225.)

Varietal Evaluation for Insect Resistance

Mathes, Ralph and L. J. Charpentier, 1963. Some Techniques and Observations in Studying the Resistance of Sugarcane Varieties to the Sugarcane Borer in Louisiana. Proceedings of the Eleventh Congress of the International Society of Sugarcane Technologists.

CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling of sugar crops. The cost of harvesting and farm handling of these crops is costly and reduces returns to the producer. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

USDA PROGRAM

Equipment and methods for harvesting sugarcane are under study at Houma, Louisiana, in cooperation with the American Sugar Cane League.

A contract with the University of Sao Paulo, Brazil, provides for investigations in mechanization of sugarcane production. Its duration is for five years and involves P. L. 480 funds with approximately $49,000 equivalent in Brazilian cruzeiros.

The Federal engineering effort devoted to research in this area totals 1.0 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

SUGARCANE HARVESTING EQUIPMENT

Cutter-Cleaner-Loader Type Sugar Cane Harvester. Major design and construction changes consisting of a gatherer system and a planetary drive for the main ground drive wheels were made on the USDA experimental sugar cane harvester. The purpose was to reduce ground loss, to improve the handling of lodged canes, and to improve the overall machine efficiency and performance. These investigations are in cooperation with the American Sugar Cane League who provided both program direction and financial assistance.

Gatherer Assembly for Down Cane. A telescoping gatherer assembly was developed with a wide adjustment range for permitting the lower unit to be positioned near the ground for picking up lodged canes but at the same time providing sufficient topper adjustment range for correct topping. A gatherer drive independent of the forward travel of the machine provided speed changes needed for assistance in gathering the lodged canes. Although significant progress was made in gathering down cane with the telescoping attachment, further improvements are apparent and will be pursued.

Harvester Losses Due to Strippers. In three comparable tests of stripper arrangement, the average quantity of trash was 5.0 percent for upper and lower strippers as compared with an average of 6.9 percent when the strippers were omitted. The quantity of trash for all tests averaged 4.0 percent, which ranged from a minimum of 2.9 percent to a maximum of 14.4 percent as compared

with the plantation season average of 7.7 percent. The life of the snap-in type rubber finger strippers averaged 9.0 tons per finger before breaking. This represents a direct finger replacement cost of 3.6 cents per ton of sugar cane harvested. Further study of efficiency of both upper and lower strippers are necessary to establish their effectiveness on different varieties of cane and a wider range of crop conditions.

Harvester Efficiency. Harvester efficiency for six field tests averaged 95.8 percent, ranging from 88.9 percent for badly lodged and bored sugar cane variety C.P. 48/103 to a maximum of 97.3 percent for erect but bored C.P. 52/68 variety. The results on the effect of stripping on ground loss were not statistically significant. Field observations indicated variations of bored damage and cane erectness within the field may impose greater differences than those being measured.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Sugarcane Harvesting Equipment

Ramp, R. M. 1962. Development of a Cutter-Cleaner-Loader Sugar Cane Harvester for Use in Louisiana. ARS 42-66, July.

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH
SUGARCANE - PROCESSING AND PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. Quotas established by the Sugar Act effectively prevent the accumulation of surpluses by limiting production to estimated requirements at stable, low prices for sugar. Prices received by farmers of the United States and Puerto Rico for sugarcane are based upon the recoverable sugar content of the cane; and the rising costs of production and processing make imperative the more efficient recovery of increased amounts of sugar to provide adequate returns for both processors and growers. Currently recovery of 75 percent of the total sugar in the cane is considered satisfactory in Louisiana, and about 83 percent in Puerto Rico and Hawaii. Improved processing methods could increase the recoverable sugar to at least 85 percent in Louisiana and over 90 percent in other areas. The development of more efficient processing methods depends in turn upon the acquisition of adequate data on the quantitative composition of juices extracted from sugarcane, and of materials processed to recover sugar. The chemical industry provides a promising potential for the utilization of additional sugar since more than 15 billion pounds of chemical products are produced annually and sold to every section of American industry. More information is needed on the chemistry and properties of products from sugar to expand their utilization and on the application of these derivatives in the production of plastics, protective coatings, emulsifiers, detergents, and the like.

USDA PROGRAM

The major part of the Department's research program on sugarcane processing and products is maintained at the Southern Utilization Research and Development Division, New Orleans, Louisiana. At the Northern Division, Peoria, Illinois, the Department maintains a long-term continuing program involving microbiologists and biochemists engaged in basic and applied research on the fermentative conversion of sugar to industrially useful organic acids.

The Federal program at Peoria, Illinois, totals 2.5 professional man-years, all of which is devoted to new and improved products, specifically, fermentative conversion of sugar to α-ketoglutaric acid.

In addition, the Department, through the Northern Division, sponsors research in this area under a grant of PL 480 funds to the Institute of Biological Chemistry, University of Rome, Italy, for studies on the preparation and characterization of dextran derivatives (5 years, 1961-1966). This research is under the subheading, new and improved products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. New and Improved Products

1. Production of α-ketoglutaric acid. Conditions have been developed for reproducible conversion of glucose to α-ketoglutaric acid in 58-percent (weight/weight) yield. Pseudomonas chlororaphis (NRRL B-560) is used for the fermentation, which requires 168 hours. A 25-percent yield of 2-keto-gluconic acid is also formed but no satisfactory method for converting it to α-ketoglutaric acid has been found. Conversion of glucose to 2-keto-gluconic acid in yields of 85 to 95 percent (weight/weight) has been achieved in 1 to 2 days in 20-liter fermentors with Serratia marcescens.

It is doubtful if more than minor improvements in yield of α-ketoglutaric can be achieved by further adjustments in fermentation conditions. The process might nevertheless prove to be economical if both α-ketoglutaric and 2-ketogluconic acids could be conveniently isolated in good recovery. The process for 2-ketogluconic acid based on S. marcescens should have industrial value and deserves further developmental research and cost evaluation.

2. Studies on dextran derivatives. Both cationic and anionic derivatives of a dextran have been prepared and their interaction with selected proteins is being investigated. Discovery of soluble complex formation between these derivatives and protein assures further progress in study of reaction mechanisms and modes of binding. One entirely new derivative might find applicability based on its exceptional water-binding capacity. Other studies were concerned with the physiochemical characterization of the dextran and on the reaction of dextran with certain oxidative and hydrolytic reagents. This research is being conducted by the Institute of Biological Chemistry, University of Rome, Italy, under a PL 480 grant.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

SUGARCANE - PROCESSING AND PRODUCTS
Southern Utilization Research and Development Division, ARS

Problem. Quotas established by the Sugar Act effectively prevent the accumulation of surpluses by limiting production to estimated requirements at stable, and normally low prices for sugar. Prices received by farmers of the United States and Puerto Rico for sugarcane are based upon the recoverable sugar content of the cane; and the rising costs of production and processing make imperative the more efficient recovery of increased amounts of sugar to provide adequate returns for both processors and growers. Currently recovery of 75% of the total sugar in the cane is considered satisfactory in Louisiana, and about 83% in Puerto Rico and Hawaii. Improved processing methods could increase the recoverable sugar to at least 85% in Louisiana and over 90% in other areas. The development of more efficient processing methods depends in turn upon the acquisition of adequate data on the quantitative composition of juices extracted from sugarcane, and of materials processed to recover sugar. The chemical industry provides a promising potential for the utilization of additional sugar since more than 40 billion pounds of chemical products are produced annually and sold to every section of American industry. More information is needed on the chemistry and properties of products from sugar to expand their utilization and on the application of these derivatives in the production of plastics, protective coatings, emulsifiers, detergents and the like.

USDA PROGRAM

The Department has a continuing long-term program involving at the Southern Utilization Research and Development Division organic chemists and chemical engineers engaged in basic research on the composition and properties of sugarcane, sugarcane juices and derived products, and in applied research directed to the development of new and improved sugarcane processing technology.

Basic and exploratory studies are being carried out at New Orleans, Louisiana, on the composition of sugarcane and sugarcane juices as a basis for developing more efficient methods for economical production of high grade end products. Materials used in this research are being obtained from cane processed for pilot-plant experiments in cooperation with the American Sugar Cane League.

Research on new and improved processing technology is being conducted at New Orleans, Louisiana, the U. S. Sugarcane Products Laboratory, Houma, La., and the Audubon Sugar Factory (Louisiana State University), Baton Rouge, Louisiana, to develop on a pilot-plant scale novel and more effective means of clarifying sugarcane juice, and improved methods of processing and purifying sirups to obtain greater recovery of raw sugar of higher quality at lower costs. This research is planned and conducted in close cooperation

with the American Sugar Cane League and individual sugar companies. Sugarcane for the work is furnished by the League and use of the Audubon Factory for milling of the cane through the cooperation of Louisiana State University. Cooperation is also maintained with the Crops Research Division, ARS (U. S. Sugarcane Field Station, Houma, La.). Informal cooperation is maintained with the industry in evaluating quality of raw sugar and economic aspects of new processing methods.

Other research on chemical composition and properties has been initiated under a grant of P. L. 480 funds to Kyoto University, Kyoto, Japan, for isolation and identification of the nucleic acid derivatives of cane molasses, in order to obtain information applicable to expanding the utilization of molasses industrially and in feeds (project duration - 2 yrs.).

The Federal in-house scientific effort at the Southern Division devoted to research in this area totals 10.8 professional man-years. Of this total 3.7 are devoted to chemical composition and physical properties and 7.1 to new and improved processing technology. P. L. 480 research involves 1 grant for research on chemical composition and physical properties.

During the year emphasis on pilot-plant development of new and improved methods of clarification was reduced somewhat to permit initiation of promising research to investigate the qualities of clarified sugarcane juices in relation to the refining quality of raw sugars.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Basic Studies of the Chemical Composition and Physical Properties of Sugarcane Juice and Its Products. Basic studies were continued to gain more complete knowledge of the composition and properties of sugarcane juice and its products. Further study of the two water-soluble polysaccharide fractions of the gums present in juice solids and molasses showed that alcohol precipitation effects the separation of fraction A, with very little occlusion of fraction B which is obtainable by adsorption on carbon. The alcohol-precipitable gum (fraction A) from juice solids contained 37.5% glucose, 6.2% fructose, and had a specific rotation, α,of + 67°. This gum could be separated into two sub-fractions by alcohol precipitation--one having α + 161° and 7.1% fructose; the other, α + 133° and 19.2% fructose. Starch was not present in these materials. The non-alcohol precipitable gum (fraction B), which was separated and determined on carbon-Celite columns, contained 40.2% glucose and 14.0% fructose. The fact that fructose is a major constituent of the various fractions of water-soluble sugarcane gum is an important new finding.

Methods were developed for determining pentose content, in addition to the other component sugars, in the gum fractions of juices, sirups and molasses. Routine procedures have also been devised for the separation and estimation

of starch and gum fractions A and B in sugarcane products. In connection with the starch work, sugarcane starch was isolated and found to give the same iodine color yield as Baker's soluble starch used as a standard in colorimetric starch determinations. In completed work on the determination of the amounts of the trisaccharide, kestose, in juices, concentrations approximating 0.3% were found in three samples of lyophilized juice solids. The concentration of mannose in a sample of Florida molasses was determined in cooperative work with the New York Sugar Trade Laboratory.

Knowledge of the chemical and physical properties of the minor constituents of sugarcane will aid in the pilot plant studies on new methods of clarification. Methods for the quantitative determination of these constituents are essential in order to determine the effectiveness of various clarifying agents and procedures. The measurement of the physical properties such as the specific rotation of the polysaccharides from the various stages of processing may indicate whether bacterial polysaccharides are formed. The formation of such polysaccharides in addition to the natural polysaccharides already present would represent a loss of sugar as well as an interference in subsequent steps in processing and refining. (S5 1-71).

B. New and Improved Processing Technology

1. Improved Processing Procedures for Clarifying Sugarcane Juice. Experiments were continued to improve methods of clarification of sugarcane juice. A definite relationship has been established between phosphate content of mixed juice and its response to lime clarification over a wide phosphate range. Clarity, filterability, and clarification efficiency values increased correspondingly with phosphate, reaching a maximum at 0.6 pounds of phosphate (as P_2O_5) per ton of cane processed. Clarification quality gradually deteriorated as the phosphate content increased beyond this optimum value. Phosphate content of mixed juice could become an important factor in cane variety and selection and in promoting selective harvesting and cane blending at the mill to insure maximum juice clarification efficiency and the production of high quality raw sugar. Limiting the variations in phosphate concentration would also insure a more uniform mud rate to the filters, and allow maximum capacity factory operation during a higher percentage of time.

Two cationic and one anionic flocculant were investigated in further experiments to improve the clarification of sugarcane juice. The anionic, Separan AP-30, continued to yield greater improvement in settling. Best results were obtained with the combination of Separan and bentonite in clarifying juices from clean cane. Limited tests were made to explore possibilities of magnesia and starch, with negative results.

In cooperative work with Southdown, Inc., a novel test procedure (Millipore filtration test) has been found to give good correlation of the filterability of sirups with that of raw sugars produced from them, but no significant relationship of clarified juice filterability to sugar quality. The

The Millipore test of sirups and sugars at average juice density, 15% solids, is more sensitive than the standard pressure filtration of high density refinery sirups, and showed a relationship to refinery experience in processing the raw sugars which the standard test failed to reveal. A large commercial refiner is extremely interested in the possibilities of the novel test for evaluating raw sugars.

Standard pilot-plant processing experiments to evaluate four new canes were conducted during the 1962 harvest season. The data obtained will be used by the American Sugar Cane League in evaluating processing characteristics of the commercial and unreleased canes. (S5 1-70).

2. Composition of Sugarcane in Relation to Processing. Compositional work on juices from freeze damaged canes (1960 and 1961 seasons) has been completed. The data on the non-sugars in such juices which affect processing quality should be helpful in devising the most efficient means for processing freeze damaged canes.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

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New and Improved Processing Technology

Coll, E. E. (SURDD); Davidson, L. G. (Crops Research Div., ARS); Stewart, C. W. (Audubon Sugar Factory, LSU); and Guilbeau, W. F. (SURDD). 1962. Milling and processing qualities of cane combined in short pieces compared with whole-stalk burned cane. Sugar Bull. 40, pp. 212-219

Coll, E. E. Guilbeau, W. F., Fort, C. A., and Jackson, J. T. 1963. Comparative pilot-plant tests on a few approaches to sugarcane juice clarification. Sugar Bull. 41, pp. 110-115

Guilbeau, W. F., Coll, E. E., and Jackson, J. T. 1962. Sugarcane mud filtration. Sugar Bull. 41, pp. 62-66. Republished: Intern. Sugar J. 65, pp. 141-143 (1963)

Smith, B. A. (SURDD); Sanchez-Nieva, F., Vasquez-Romero, R., and Carlo-Velez, L. A. 1963. Production of liquid sugars. Ion exchange adapted to confectionery in Puerto Rico. Sugar y Azucar 58(4), pp. 33-36

General

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SUGAR BEETS - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. Sugar beets are mainly processed for sugar; a very small proportion is used for livestock feed. Sugar beets are declining in sugar content and rising in impurities. The traditional processing methods for sugar manufacture cannot cope with beets whose lower quality is due in part to excess nitrogen fertilizer, used to improve tonnage yields. Improved processing procedures should benefit both the growers and processors. It is known that small concentrations of certain chemicals in beets affect processing quality but not enough information is yet available to devise new economical procedures for high-impurity beets. Because costs of producing beets and processing sugar are rising whereas consumption and price of sugar are essentially constant, all factors important to utilizing the crop must be examined to improve processes. There is still too much ignorance of the composition of sugar beets, juices, pulp, and crude sugar to achieve this objective. Sugar losses resulting from spoilage and respiration of beets held at processing plants cannot be prevented by existing methods. Only an expanded research program can provide the needed information at an early date.

USDA PROGRAM

Both basic research and process development studies on sugar beets are being conducted in the Western Utilization Research and Development Division's headquarters laboratory at Albany, California and under P.L. 480 grants, in Calcutta, India, Jerusalem, Israel, and London, England. The basic research program involves a comprehensive study of the naturally-occurring sugar beet and beet juice constituents, both carbohydrate and non-carbohydrate. Biochemical studies of the carbohydrate constituents aim to determine their origin leading to the development of methods for the reduction or elimination of those which decrease sucrose. Chemical studies of the non-carbohydrate constituents provide information to ameliorate effects of adverse constituents. Although Federal research on new products from sucrose (sucrochemicals) has been terminated, studies continue under P.L. 480 grants on the reactions of sucrose with vegetable and animal fats and oils, to produce new and useful compounds having special hydrophilic and lipophilic properties. Processing research on sugar beets deals with the effects of the many variables which influence the efficiency of recovery of sucrose. Pilot-scale sugar beet processing facilities are used to test these processing variables and to evaluate new and improved processing techniques.

The Federal program of research in this area totals 5.8 professional man-years. Of this total, 2.1 are assigned to chemical composition and physical properties; 3.7 to new and improved products and processing technology. In addition the Division sponsors, under P.L. 480, one basic research project and two on product developments.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Carbohydrate Constituents. Basic studies are under way to isolate and purify non-sucrose carbohydrates from beets for use in studying reactions that interfere with sucrose recovery. A one-step methylation procedure was adapted to convert beet carbohydrates into methylated derivatives volatile and stable enough for separation by gas-liquid chromatography and thin-layer chromatography so they could be identified. Previous studies indicate that galactinol, a beet carbohydrate, as well as raffinose, interferes with the yield of sucrose and should be further investigated. Pure galactinol has now been crystallized and is available as a reference standard in studies aimed at improving the efficiency of sugar recovery from beets.

Investigations on galactose and galactose-containing constituents of sugar beets led to a simple, sensitive test for galactose. This test is now helping to diagnose a rare but severe metabolic disease in infants. This disease, called galactosemia, occurs in certain children born unable to metabolize galactose, and gives rise to jaundice, liver damage, cataracts, and mental deficiency. It can be successfully treated only when detected within a few days after birth. Treatment is to avoid galactose in the diet. The test can be used routinely to diagnose galactosemia by detection of galactose in urine or blood samples and to check foods for galactose so that a safe diet can be prescribed. An enzyme, galactose oxidase, required for this test is now commercially available.

2. Non-Carbohydrate Constituents. The role that chlorides play in the recovery of sucrose from beet juice has been previously reported. When the content of chloride is high, sucrose recovery is low. The recovery of sugar from beets, the chloride content of molasses, and the purity of molasses were found to be closely related. Now it has been shown that the chloride content of thin or thick juice, as well as the chloride content of molasses, is useful in predicting the purity of the molasses that will be produced. Preliminary tests of juice from two factories, using a chemical method to determine sucrose remaining in the molasses, agreed with the purity value predicted by the chloride analysis.

Contract research on the effect of genetic and agronomic factors on non-sugar constituents of sugar beets has been concluded at Colorado State University. The final report indicated that a new F_1 hybrid sugar beet variety has lower chloride and soluble nitrogen contents under all fertility levels studied than the control beets. High yielding beet varieties with low chloride and nitrogen impurities despite heavy fertilization would materially increase returns to growers, while eliminating troublesome and costly processing problems.

3. Enzymic Sucrose Degradation in Sugar Beets. A study of the enzymic sucrose degradation in sugar beet tissues, to provide information necessary for development of improved procedures for handling beets for processing, was initiated under P.L. 480 at the Hebrew University, Jerusalem, Israel. Experimental procedures were developed to handle the beet roots after harvest, to extract beet tissue to provide maximal enzymic activity, and to adapt various quantitative analytical and chromatographic procedures. Several intermediate chemical compounds, especially in the nucleotide-sugar category, were synthesized with radioactive carbon or phosphorus as substrates in the enzymic studies. Several enzymic pathways are being studied to obtain more information on the biosynthesis of sucrose in the beet root.

B. New and Improved Products and Processing Technology

1. Sucrochemicals. The domestic Federal program of research on sucrochemicals was terminated in response to recommendations of the Sugar Research and Marketing Advisory Committee. Prior to termination, negotiations had taken place to provide P.L. 480 grants for work in this area. At the Tropical Products Institute in London, England, novel and patentable processes were discovered for preparing from sucrose and derivatives of animal fats compounds exhibiting a high degree of surface activity which may be of considerable commercial value as surfactants. In addition to providing a market for sugar, they could increase use of animal fats which are presently in critical surplus. Chemical processes were discovered to provide greatly simplified, direct routes for preparing ethers of organic polyhydroxy compounds. With a highly reactive molecule, sucrose, serving as the polyhydroxy compound, long-chain alcohol derivatives from animal fats are readily combined to form ethers. Such ethers, for example, mono- and di-dodecyloxymethyl ethers of sucrose have considerable surface activity and may also find use in wetting, dispersing, penetrating, and emulsifying agents. A patent application is being filed in the United States to cover the processes discovered and, when issued, will be assigned to the United States Government and be available for free licensing by manufacturers within this country.

Basic research on the reaction of sucrose with sulfonyl chloride and similar compounds, to provide substances for manufacture of polymers, was initiated at Jadavpur University, Calcutta, India. Initiation was hampered by difficulty in obtaining trained scientists and import licenses for essential chemicals and apparatus. However, a literature search was made and a review was published to form a firm foundation for the laboratory work that is just being initiated.

2. Juice Diffusion. Investigations are continuing with the objective of improving diffusion processes whereby a higher recovery of sugar from beets may be obtained in the initial extraction. It was previously reported that laboratory and pilot plant tests indicated an improved method of utilizing the two usual sources of water for sugar diffusion (i.e., well water

normally containing natural salts, and distilled water recovered from the evaporation of sugar juices). By adding the stream of well water at the tail end of the diffuser and the pure distilled water somewhere toward the head end, purer sugar juices were obtained. The impurities in the well water were largely eliminated by the exhausted pulp as it leaves the diffuser. One beet sugar company, operating in an area where well waters are saline, has applied the diffusion scheme with good success and others are currently evaluating the process.

Another investigation towards improving the diffusion of sugar from beets is concerned with an alkaline treatment of the cut beets to modify the natural pectin. About 30% of sugar beet insoluble solids is pectin. Alkali will interact with the pectin in sugar beet cossettes. At low temperature the principal reaction breaks chemical linkages in the large pectin molecule forming pectic acid and acetic acid. At high temperatures the large pectin molecule is broken into smaller fragments by degradation. Degradation reduces the mechanical strength of the tissue and hinders diffusion of sugar and dewatering of exhausted pulp. Laboratory trials indicated that a carefully controlled lime treatment of sugar beet cossettes at low temperature stabilizes the pectin molecule and enhances the diffusion, leaving a tough, readily pressed pulp. More water can be pressed from the pulp providing a greater quantity of thin juice and a drier, more easily handled pulp; the overall lime consumption is less than in usual diffusion-plus-carbonation of the juice to remove impurities at a later stage in the refining. Variables resulting from lime treating the cossettes will be subjected to further laboratory examination and pilot plant studies prior to cooperative trials on larger scale equipment.

3. Juice Purification. Laboratory tests were conducted to find better methods for purifying thin juice extracted from sugar beets. Preliminary work with static columns indicate that glucose and ionic impurities can be separated from sucrose by ion and molecular exclusion. Removal of such impurities, if it can be accomplished on a commercial scale, should improve the efficiency of sugar recovery from beets. Experiments made with a hot column using diluted molasses showed better purification of sucrose and higher concentration than similar experiments using a cold column. However, there appear to be one or more amino compounds that cannot be easily separated from sucrose using hot columns, even though removal of color in certain fractions was very good. Investigations will continue to seek methods for improvement in purification methods.

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III. MARKETING AND ECONOMIC RESEARCH

MARKET STRUCTURE, PRACTICES AND COMPETITION
Marketing Economics Research Division, ERS

Problem. Most agricultural processing industries continue to experience rapid and drastic changes in their market organization and their marketing and merchandising practices. These changes affect both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. Continuing changes in structures and practices alter the basic economic functions for which markets are responsible and involve both technical and economic efficiency.

Increasing concentration, changing institutional patterns, and shifts in marketing channels and practices have created a new economic climate in which the farmer must live. As a basis for rational adjustments to this changing environment, information is needed (1) to indicate impacts of vertical and horizontal integration, other changes in market structure or marketing practices, and the development of new institutional arrangements upon farmers' bargaining position and income and upon the effectiveness and efficiency of the marketing system; and (2) to determine types of public action which would be most effective.

USDA PROGRAM

The Department has a continuing long-term program of economic research to assist farmers and marketing agencies to adapt to changes in market structure, practices and competition. The Federal effort concerned with marketing economic research on sugar totals two professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

1. "Eastern" Beet Sugar Marketing Problems. Beet sugar growers and processors in Michigan have a strong interest in an evaluation of the competitive position of sugar beets, molasses, and beet pulp, produced by the "Eastern" sugar beet industry. They also need information on improvements which will assist producers, processors, and others in adjusting to changes in marketing conditions. Partial results of this nearly completed study indicate that under recent price relationships sugar beets possess considerable advantages over alternative crops available to farmers in the area. However, other competitive conditions in this sugar producing area are unusually severe and these may limit the increase of sugar production in the area from that which might be expected.

2. Economics of Marketing Sugar. A slow decline in the relative proportion of sugar and an increase in the use of corn sirup as a sweetening material has occurred in most food industries since World War II. The use of non-caloric sweeteners by soft drink bottlers is increasing rapidly. Lower costs for corn sirup and non-caloric sweeteners relative to sugar are important factors causing these changes.

Dextrose and corn sirup are accounting for increased proportions of the increase in industrial use of caloric sweeteners. During 1952-56, they accounted for 10 percent of the increase; by 1956-61, to 27 percent. If this rate of gain over sugar continues, by 1981 all the gain in industrial use will be by dextrose and corn sugar. The results of this study indicate the need for rigorous economic evaluation of the current phase of this industry, and public policies relating to sugar prices, production, and marketing. Such an evaluation is now in progress.

3. Marketing Industrial Molasses. Molasses in each of its major uses is subject to effective competition from alternate raw materials. In livestock feed, other materials may be used. In most chemical uses, petroleum gases or other materials may be used to produce identical products. This substitution limits the price response of molasses to smaller supplies. Work on this project was initiated only recently.

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